An Effective Object Recognition Algorithm Based on Multi-source Remotely-sensed Image Fusion

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Abstract

The paper proposed a feature selection algorithm through high step association analysis, mined the various features of object recognition using property related analysis, the sensitive recognition features were chosen to improve the recognition efficiency. A recognition algorithm based on complementary features of multi-source remote sensing images was presented. The experiment results showed the algorithm had effectively improved the accuracy of bridge recognition.

Keywords

Fusion on the Decision Level; High Step Association Analysis; Object Recognition; Multi-spectral Image; Panchromatic Image; SAR Image

Introduction

Target recognition is an important branch of artificial vision, and has great application value in various fields (Peeters A, Etzion Y., 2012). A big problem in target recognition technology is missing and false alarm. The main reason for missing and false alarm is the single sensor image which is not sufficient for the target description, and the information cannot reach the purpose of recognition. Multi-sensor integrated target recognition is a synthesis of information provided by multiple sensors in the system, makes full use of the advantages of each sensor in order to improve target recognition rate. This paper mainly studied the water bridge recognition method based on multi-source remote sensing image fusion.

Feature Analysis and Extraction of Multi-source Remote Sensing Images

Feature Analysis of Multi-source Remote Sensing Images

In multi-spectral images, the width of usual large bridges is only 1-3 pixels, the length is less than 20 pixels, extraction bridges often appear missing or false alarms. The color of waters and lands has greater difference, so the color feature in multi-spectral images can be used to extract waters and potential bridge areas.

Panchromatic images have less spectrum, it is difficult to meet the application requirements. In bad weather conditions, the atmospheric penetration ability is poorer, imaging capability is poorer in the night. The bridge features in panchromatic images are significant, but it is difficult to extract the river regions and distinguish the waters and bridges, the computing complexity is too large by using the texture feature extraction waters in panchromatic images.

SAR images have advantages such as all-weather, good penetration, large area imaging with high sensitivity, vast role distance. The gray value of artificial target is significantly higher than other targets in SAR images (Pelli Denis G., Cavanagh Patrick, 2013), it is easy to extract artificial targets, but it is difficult to distinguish between the bridge and the other artificial objects. Due to the influence of imaging mechanism for SAR images, there are a lot of speckle noises; it is a large effect for target recognition (Lillywhite, Kirt, Lee Dah-Jye, Tippetts Beau, 2013). The bridges often exist in fractures, no good properties of parallel lines. Bridge recognition algorithms for SAR images are still in the initial stage, the fracture and the false alarm problem has not been well solved. Due to the noise and shadow effects, bridge position deviations may also exist, and it needs to find a better algorithm for accurate positioning and target recognition.

Mathematical Theory for High Step Association Analysis

At present, mathematical methods of handling correlation and relation level include two ways, one is mathematical statistics way based on probability

distribution and statistical analysis, such as regression analysis and variance analysis etc., which needs a lot of samples that have better distribution regularity. Another is analysis method of relation level in grayed system theory, it takes developing situation as a foothold, does not excessively request the quantities of samples, also does not need typical distribution regularity, and calculation is less.

In present methods, linear correlation level is mainly considered, which makes it difficult to find out the rule hidden in data. The paper presents a method that is high-order association analysis, which can offer intrinsic relation between factors, so it may provide evidence information for object recognition.

The description of relationship between random variables involves two concepts, one is covariance $Cov(X,Y)=EXY-EXEY$, or correlation coefficient

$$\rho_{xy}=\frac{Cov(X,Y)}{Var(X)^{1/2}Var(Y)^{1/2}}$$

Where $Var(X)$ and $Var(Y)$ are the variances of variable X and Y respectively. X and Y are not correlative, which is equivalent to $Cov(X,Y)=0$. The other is independence, that is, $F(X,Y)=F(X)F(Y)$, where $F(X,Y)$ is a joint distribution function, $F(X)$ and $F(Y)$ are both distribution functions. The correlation coefficient is easy to compute, whereas the independence is difficult to prove.

From the nature of correlation coefficient, we know $|\rho_{xy}|\le 1$ and $|\rho_{xy}|=1$ if and only if X and Y are linear correlation whose probability is 1, i.e., there exist constants a and b, so that: $P\{Y=ax+b\}=1$. This formula expresses the linear relation between X and Y.

Example 1. Let $Y=\cos(X)$, $X\sim N(0, 2\pi)$, where $N(0, 2\pi)$ is a uniform distribution. Then we can get the following results.

$$\rho_{xy}=0.0491,\ \rho_{x^2y}=0.234,\ \rho_{x^3y}=0.345,\ \rho_{x^4y}=0.463,$$
$$\rho_{x^5y}=0.517$$

The computed results show that $Cov(X^k,Y)$ or ρ_{x^ky}, $k=1,2,3,\ldots$, can describe the hidden nonlinear correlation, so we introduce high-order correlation.

Definition. If there exist two positive integers k,l such that $Cov(X^k,Y^l)\neq 0$, then we say there is (k,l)-order correlation between X and Y. $Cov(X^k,Y^l)$ is called (k,l)-order covariance and $\rho_{x^ky^l}$ is called (k,l)-order correlation coefficient.

It is obvious that ρ_{xy} is the simplest situation while $k=l=1$. If $k>1$ or $l>1$, then we say there is high-order correlation between X and Y. If $\rho_{xy}=0$, it only shows that there is no obviously linear correlation between X and Y, but it is unknown whether nonlinear relation exists or not. If there exist two integers k, l such that $\rho_{x^ky^l}\neq 0$, then we say X and Y are of (k,l)-order correlation. When $\rho_{x^ky^l}=1$, we call it positive (k,l)-order correlation. When $\rho_{x^ky^l}=-1$, we call it negative (k,l)-order correlation. If $|\rho_{x^ky^l}|<1$, (k,l)-order correlation level weakens along with $|\rho_{x^ky^l}|$ reduces. It is all known that if X and Y are independent, there exist all positive integers k,l such that $\rho_{x^ky^l}=0$, then they are not correlative.

Theorem. Suppose that X and Y are two random variables, EX^k, EY^l and EX^kY^l all exist and are limited, then X and Y are independent if and only if $EX^kY^l = EX^k\, EY^l$, for $k,l=1,2,\ldots$.

Proof can be seen in document (Wang Mingang, Wang Chao, Fan Yingping, 2012) . High-order correlation can not only describe the hidden nonlinear correlation, but also can fill up the space between correlation and independence.

A Feature Selection Algorithm Through High Step Association Analysis

The paper extracted the low-level features such as texture, the regional mean ratio, edge length, length-width ratio, direction ratio, outline, Pun histogram entropy, mean value, variance, and high-level topological relation characteristics, adopted high step association analysis in multi-feature analysis related to the bridges, eliminated redundant features through high step association analysis, selected smaller redundancy feature subset, and the sensitive recognition features were chosen. In this paper, the feature selection algorithm based on high step association analysis was proposed, and the steps were as follows.

- Read a multispectral image, extract water areas, expand and corrode, process the adjacent relationship of water and land bridge, and get some potential bridge areas;
- Extract the low-level and high-level features for the potential bridge areas;

- Calculate the high step correlation coefficient among the features. If the absolute value of the high step correlation coefficient is larger, then both of the two feature vectors G and H are of larger correlation, the feature H is redundancy feature for the feature G;
- Give the relationship among the features, select the minimal correlation characteristics and smaller correlation characteristics associated with the other features. The minimal correlation characteristics and smaller correlation characteristics together with the feature are chosen as distinctive features for bridges.

The feature selection and recognition algorithms proposed in this paper were tested through selecting different features for a lot of images. The experiment results showed the smaller correlation feature subsets for water bridges were energy, contrast, homogeneity and the regional mean ratio characteristics, redundancy features including mean, variance, Pun histogram entropy, direction ratio, edge length, length-width ratio, and topological relation feature. In panchromatic images, smaller correlation features with the other characteristics include energy, contrast and homogeneity. In SAR images, smaller correlation feature with the other characteristics is the regional mean ratio feature. Therefore, the distinguishing bridge features cover energy, homogeneity, contrast and the regional mean ratio characteristics.

A Recognition Algorithm Based on Complementary Features of Multi-source Remote Sensing Images

The paper proposed a bridge recognition algorithm based on multi-source remote sensing image fusion, the flowchart is shown in FIG. 1. The decision-level fusion is for target recognition, decision-level fusion can be divided into OR rule and AND rule.

- OR rule. In this system, if a user is refused by subsystem H_1, subsystem H_2 verifies the user again; if adopted, the user is identified as a real user.
- AND rule. In this system, the user is only accepted by subsystem H_1 and subsystem H_2 at the same time, the user is identified as a real user.

In this paper, a final true bridge recognition result was given by OR rule for the true bridge recognition results of panchromatic and SAR images, a final false bridge recognition result was given by AND rule for the false bridge recognition results of panchromatic and SAR images.

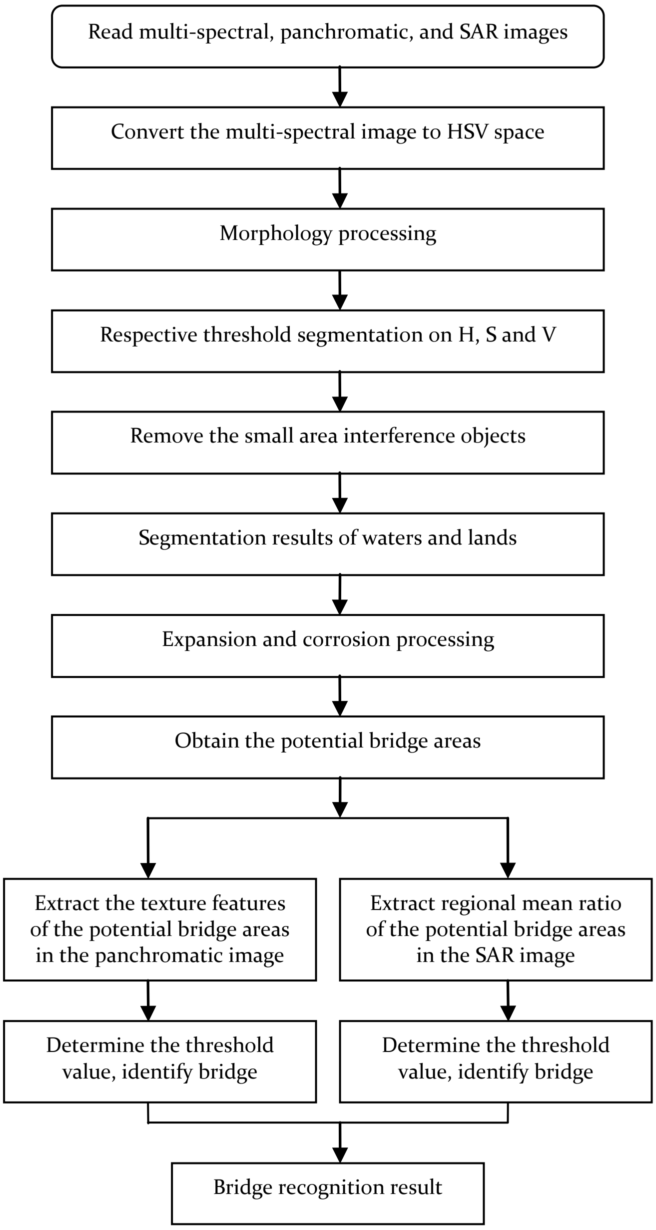
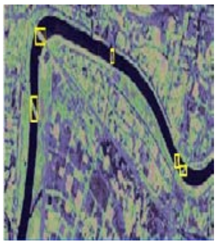


FIG. 1 THE FLOWCHART OF BRIDGE RECOGNITION ALGORITHM BASED ON MULTI-SOURCE REMOTE SENSING IMAGE FUSION

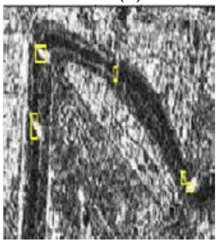
Experiment Results and Analysis

In order to verify the effectiveness of the proposed method, this paper adopted multiple sets of multi-spectral, panchromatic and SAR images in the experiment. The bridge recognition result in the panchromatic image was given priority to SAR image in order to improve the recognition rate and reliability and make up for the optical imaging remote sensing in the climate, weather, cloud cover, the existing camouflage and stealth targets. The experiment results are shown in FIG. 2.



(a) MULTI-SPECTRAL IMAGE

(b) PANCHROMATIC IMAGE



(c) SAR IMAGE

FIG. 2 THE RECOGNITION RESULTS CONTAINING FIVE WATER BRIDGES

It can be seen from FIG. 2, the bridge recognition algorithm based on multi-source remote sensing image fusion makes good use of the complementary features, significantly improves the recognition accuracy, false alarm rate is obviously lower than a single image. The main reason for missing and false alarm are as follows. The threshold value cannot adapt to all images; some bridges in the images are rather vague, and cannot identify bridges; the color of waters and some bridges is similar in multi-spectral images, some bridges are mistaken for the waters when segmenting waters and lands.

Conclusions

Feature selection and recognition algorithms were presented. The proposed method solved the problem of high complexity and false alarm for a single image bridge identification, and improved the accuracy of bridge recognition and utilization of the images.

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